USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2003NE41B

Title: Biodegradation of Dual-Contaminant Mixtures in Groundwater: Chlorinated Solvents and High Explosives

Project Type: Research

Focus Categories: Groundwater, Toxic Substances, Treatment

Keywords: Biodegradation, High Explosives, Chlorinated Solvents

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Matching Funds: $30759.00

Congressional District: 1

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Abstract: The primary goal of the proposed research is to explore conditions under which mixtures of chlorinated solvents and high explosives can be biologically degraded in contaminated soil and groundwater. Numerous sites are contaminated with nitramine high explosives (e.g., RDX and HMX, which are semivolatiles) or chlorinated solvents (e.g., tetrachloroethylene (PCE) and trichloroethylene (TCE), which are volatile organics). Some of these sites, including the former Nebraska Ordnance Plant (NOP) in Mead, NE, have mixtures of these contaminants in the subsurface. Because ex-situ treatment (pump-and-treat) is expensive, methods for remediating these contaminants in-place can potentially reduce the required time and costs for remediation. Biodegradation of chlorinated solvents and high explosives has been intensely researched over the last two decades, indicating that in-situ bioremediation may be effectively reduce the toxicity, mobility and volume of these types of contaminants. However, little is known about the feasibility of biodegrading mixtures of these dissimilar contaminants. Because high explosives and chlorinated solvents can be biodegraded separately under similar conditions, in-situ anaerobic biodegradation of mixtures of these contaminants could potentially be stimulated if an appropriate microbial consortium is present and can be activated by addition of appropriate nutrients and electron donors. This proposed research will exploit the fact that both types of contaminants can be

biodegraded under reducing conditions. The overall goal of this research is to demonstrate the feasibility of biotransforming binary mixtures of high explosives and chlorinated solvents in groundwater under anaerobic, reducing conditions. The specific objectives of the proposed research are as follows:

1. Determine the feasibility of anaerobic biodegradation of binary mixtures of chlorinated solvents and high explosives in contaminated groundwater using laboratory studies;
2. Determine the requirements for biotransforming both types of contaminants to innocuous end products, including the required nutrients, electron acceptors, and electron donors; and
3. Analyze the byproducts that are formed and explore methods for reducing the persistence of toxic metabolites.

Biodegradation of two representative contaminants, RDX and TCE, will be investigated in aboratory experiments. A facultative or anaerobic culture will be enriched from field-contaminated soil or groundwater. These media are likely to have indigenous microorganisms that can be stimulated by addition of nutrients and electron donors. If tests with contaminated media are unsuccessful, an alternate source of anaerobic bacteria (e.g., anaerobic digester sludge or an existing consortium of RDX-degraders) may be utilized for further testing. Batch anaerobic microcosms will be the primary testing method. Microcosms will be prepared in an anaerobic chamber and will be used to assess biodegradation of single and dual contaminants, as well as the efficacy of various electron or hydrogen donors such as acetate, formate, and ethanol. Kinetics of biodegradation and the effects of competition and inhibition will be evaluated. Production of toxic metabolites will be measured. Biodegradation to acceptable endpoints can be assessed by measuring production of ethene and chloride from biodegradation of TCE and production of nitrous oxide from biodegradation of RDX. After initial microcosm studies, amendments that are successful in microcosms may be tested in small-scale soil columns to simulate field conditions.
